Taste and Odor Control at the Bloomington Water Treatment Plant

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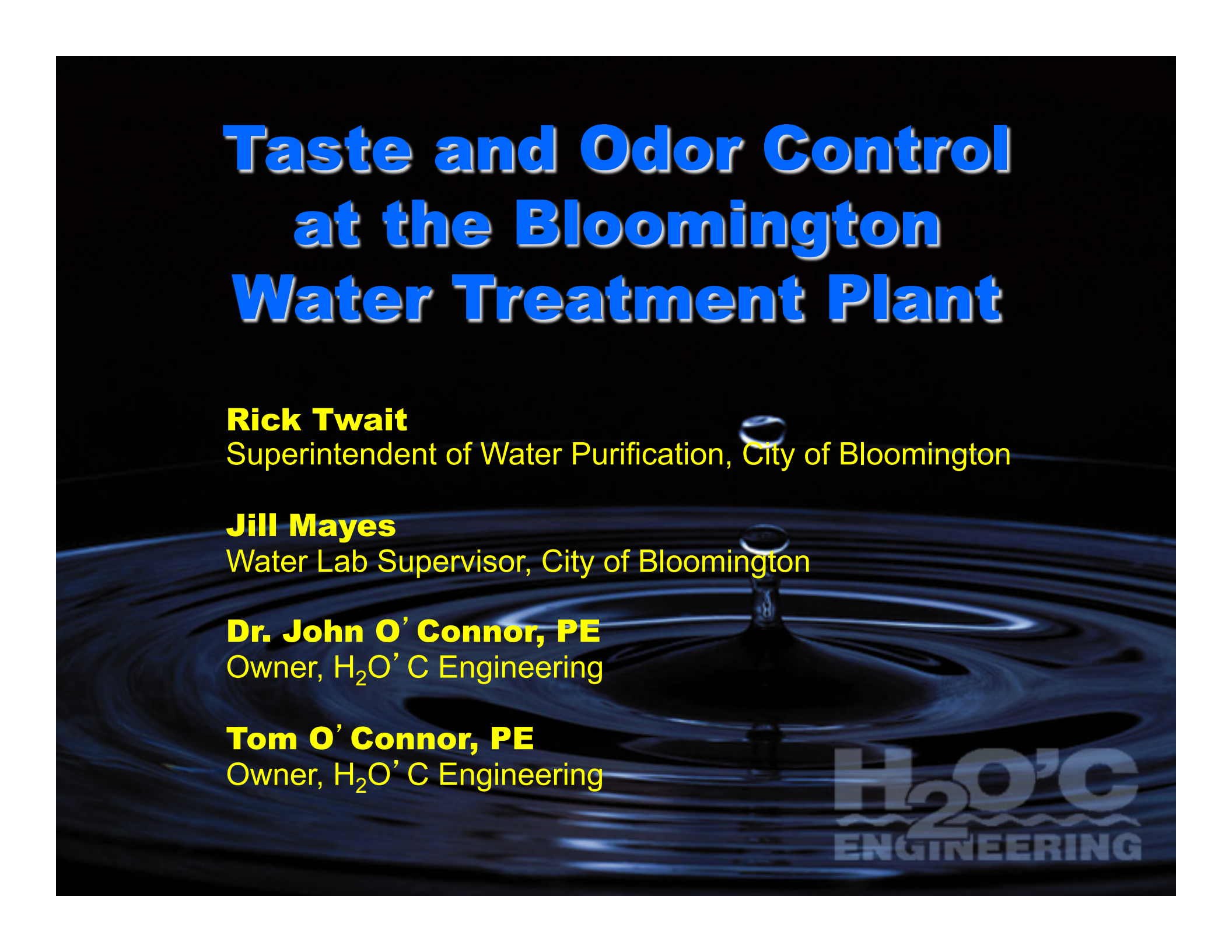
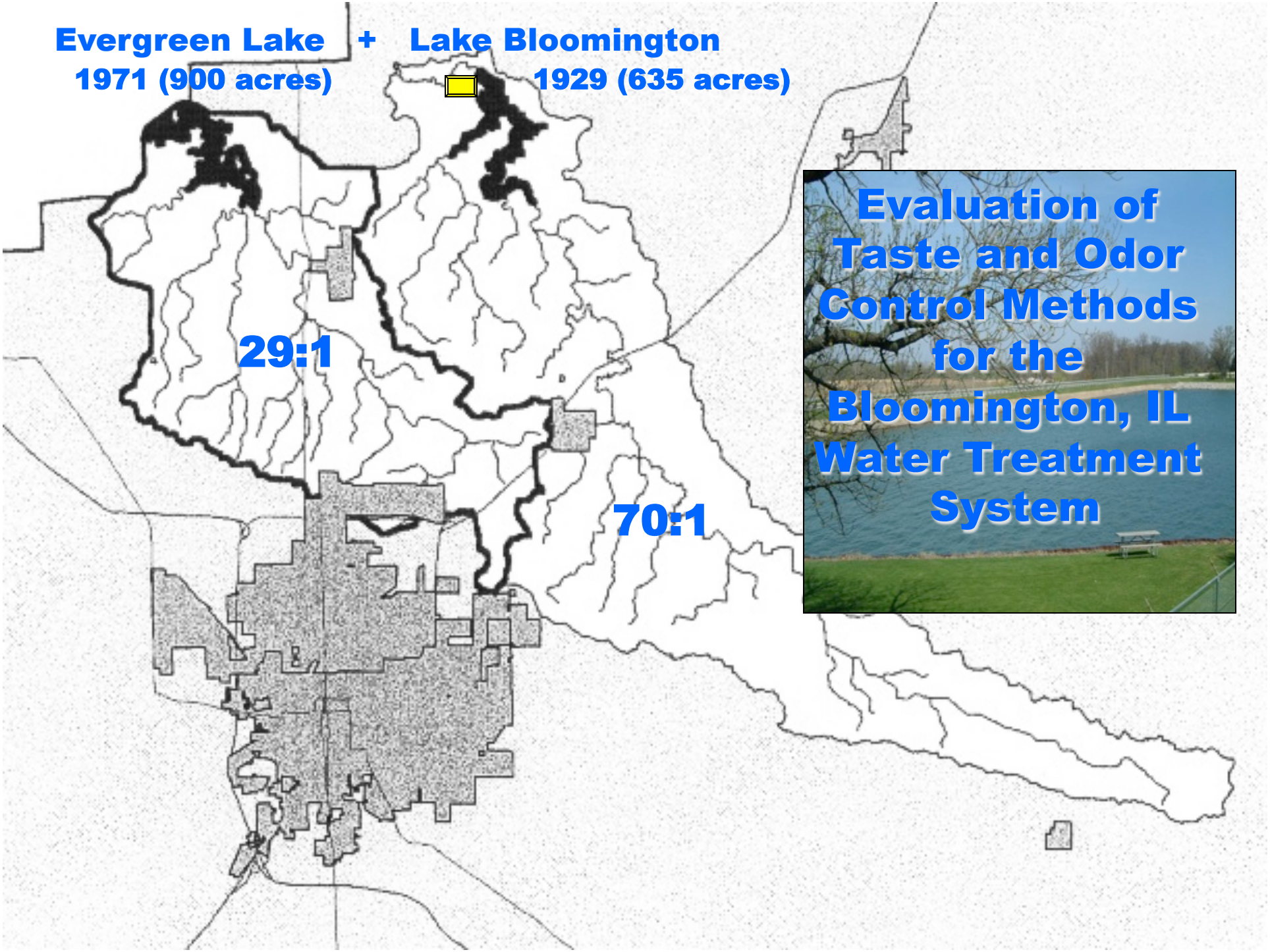



Evergreen Lake
1971 (900 acres)
+
Lake Bloomington
1929 (635 acres)
29:1
70:1
Evaluation of Taste and Odor Control Methods for the Bloomington, IL Water Treatment System

Lake and Watershed Management

Destratifiers

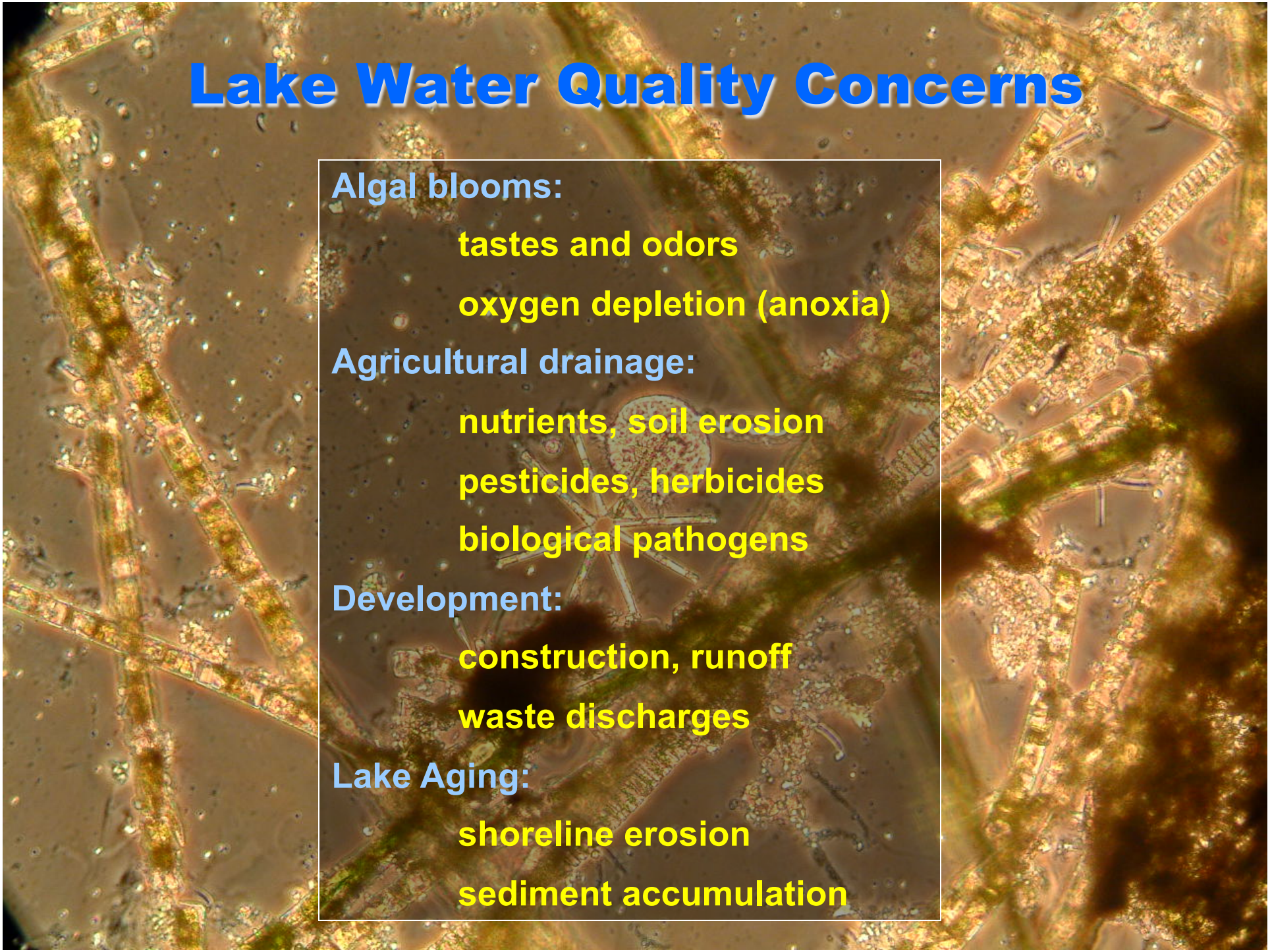
Lake monitoring

- Algal monitoring
- Volunteer Lake Monitoring Program (VLMP)

Shoreline stabilization

Tiles, streams, ponds; weekly sampling

Wetlands study: nutrient management



Lake Water Quality Concerns

Algal blooms:

- tastes and odors
- oxygen depletion (anoxia)

Agricultural drainage:

- nutrients, soil erosion
- pesticides, herbicides
- biological pathogens

Development:

- construction, runoff
- waste discharges

Lake Aging:

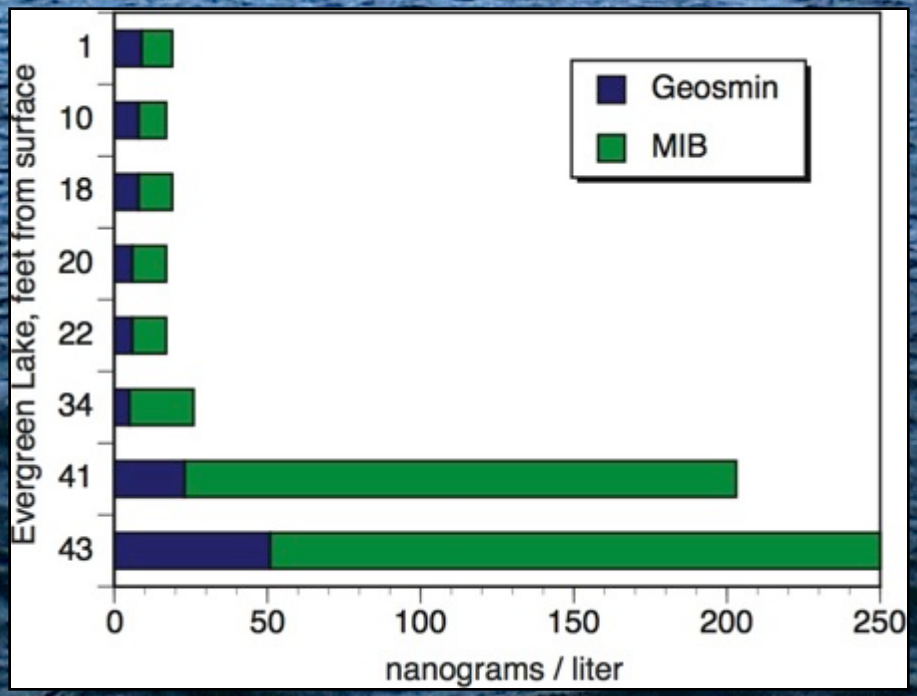
- shoreline erosion
- sediment accumulation

Bloomington Water Treatment Plant

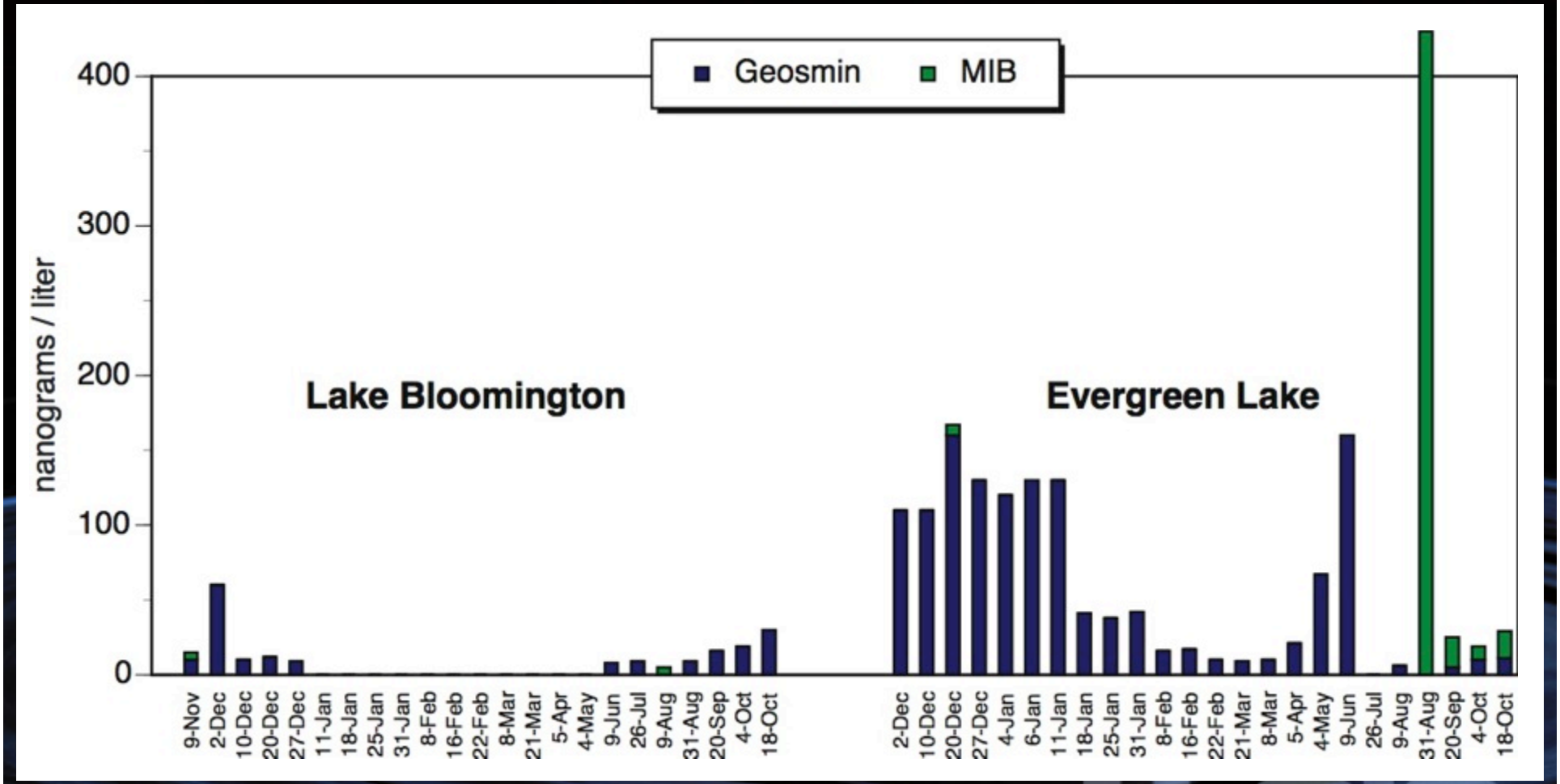
Coagulation	Ferric Sulfate + Cationic Polymer
Lime Softening	Lime Sludge → Lagoons
Stabilization	Recarbonation, Polyphosphate
Sand Filtration	Granular Activated Carbon caps


CITY OF BLOOMINGTON
EVERGREEN LAKE PUMP STATION

Evergreen Lake - Geosmin/MIB vs. Depth



Geosmin/MIB - Winter 2004



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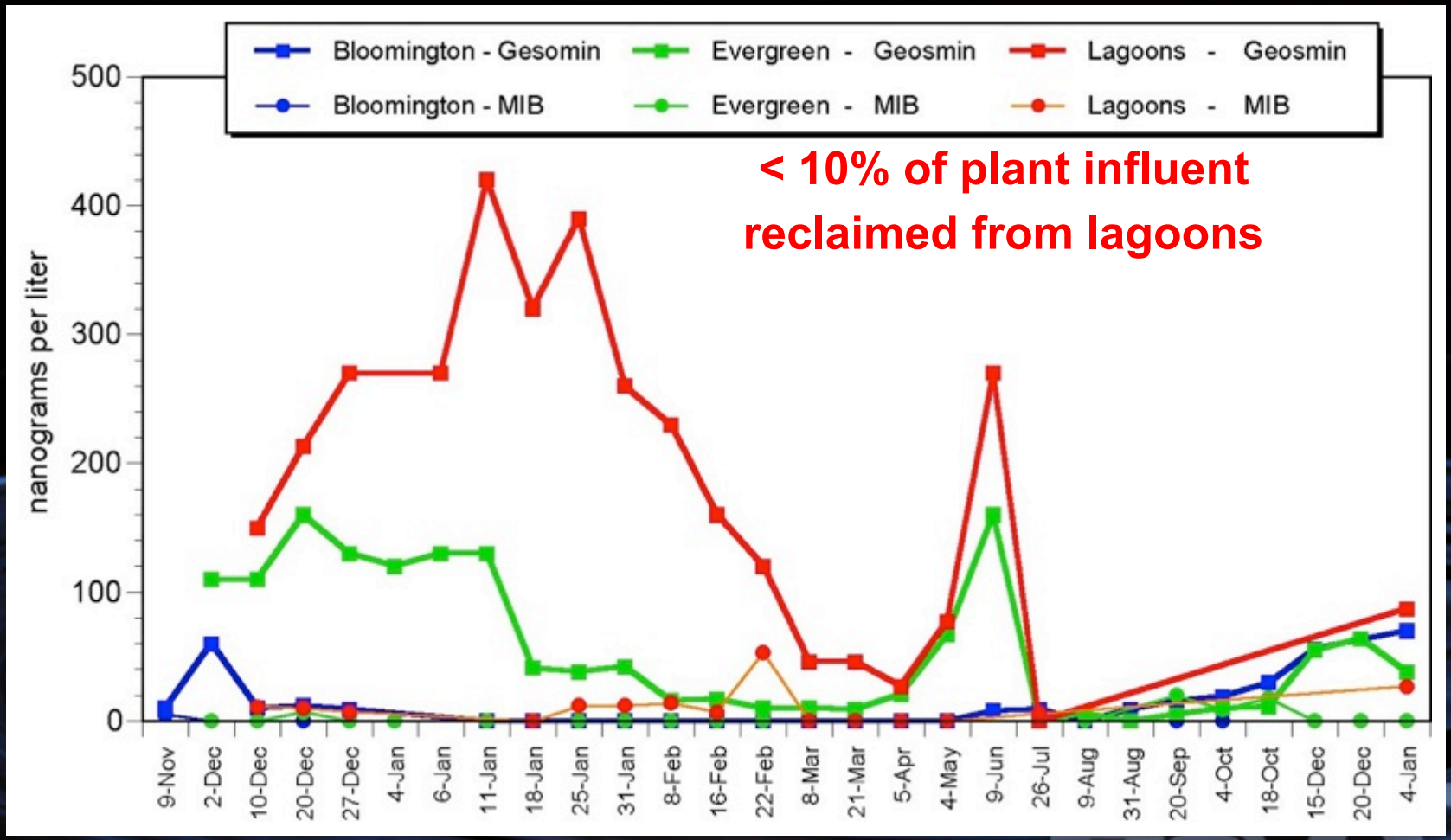
Lime Sludge Storage Lagoons

Supernatant reclaimed to WTP influent

Geosmin/MIB

Nov 2004 - Jan 2006



control/eliminate lagoon return water

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Water Plant Operational Responses for Taste and Odor Control

- increased dosage of cationic polymer (coagulant)
- reduction in filtration rates to maximize GAC EBCT
- extend filter run times to increase biodegradation
- initiation of maximum PAC feed prior to softeners
- cease prechlorination to avoid lysis of cells
- evaluation of geosmin/MIB reductions through plant
- microscopic analyses to identify algal populations

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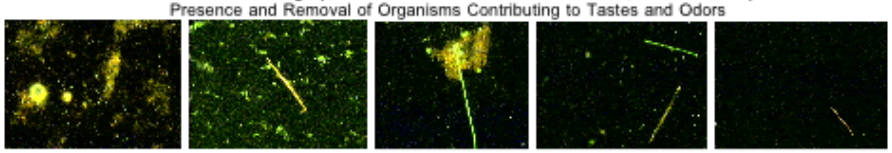
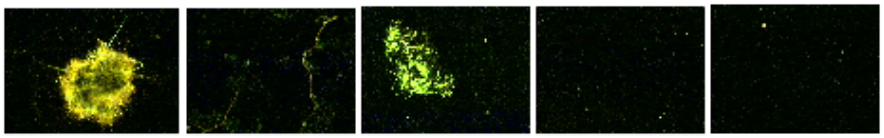
R. M. Twait's Micrographic Process Evaluation: Time Series, Source to Tap
Presence and Removal of Organisms Contributing to Tastes and Odors



Lake Evergreen **Lagoons** **Filter Influent** **Filter Effluent** **Tap** ***January 26***

*Heavy rain results in 109 ntu turbidity (**LB**), 23 ntu (**EL**), cyclotella, melosira, oscillatoria, navicula, bacteria; **lagoon** musty/fishy odor, algae; **filter influent** musty, 6.5 ntu, filamentous algae; **filter effluent** musty, 0.17 ntu, planktonic bacteria, sparse filaments; **tap water** musty, 0.17 ntu, clean, small filament lysing.*

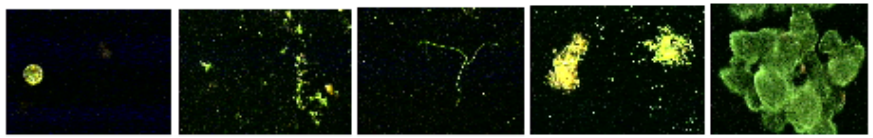


Lake Evergreen **Lagoons** **Filter Influent** **Filter Effluent** **Tap** ***January 31***

***LB** (97 ntu) stronger (fishy) odor than **EL** (23 ntu), diatoms, agglomerated bacteria, melosira colony, cyclotella; **lagoon** strong fishy odor, (1.7 ntu), decomposing filament; **filter influent** bacteria, filaments, agglomerated particles; **filter effluent** clean, planktonic bacteria; **tap water** fishy/musty, chlorinous.*

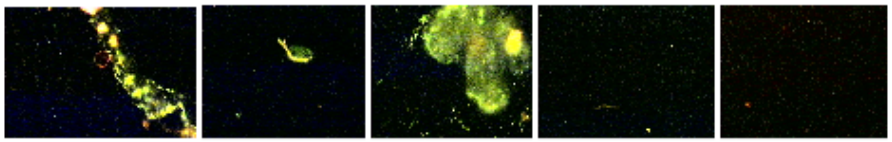
Lake Evergreen **Lagoons** **Filter Influent** **Filter Effluent** **Tap** ***February 8***

***LB** (70 ntu) earthy, **EL** (20 ntu) diatoms, filaments, melosira colony, cyclotella, asterionella, spherical bodies, fishy; **lagoon** very strong musty/fishy, filaments (1.2 ntu); **filter effluent** planktonic & agglomerated bacteria, filaments; **tap water** slight musty odor, particle-free, very clean.*



Lake Evergreen **Lagoons** **Filter Influent** **Filter Effluent** **Tap** ***February 16***

***LB** (50 ntu) no odor, **EL** (20 ntu) astringent odor; **filter influent** long spiral bacteria, centric diatoms, melosira, cyclotella, fragillaria colony, crystals; **filter effluent** musty/fishy, planktonic & agglomerated bacteria; **tap water** strong chlorinous odor, carbonate crystals (particles absent in most fields).*



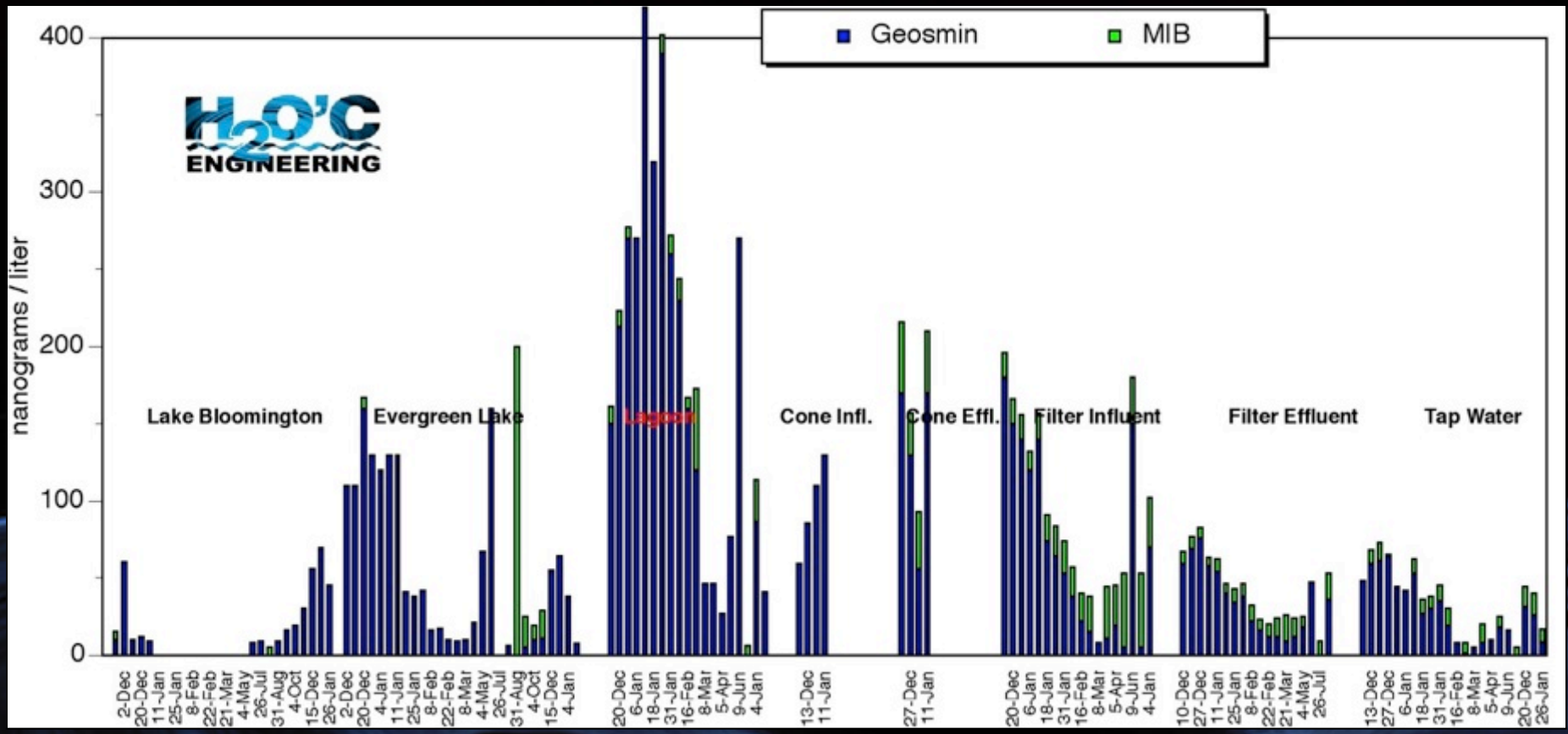
Lake Evergreen **Lagoons** **Filter Influent** **Filter Effluent** **Tap** ***February 22***

***LB** (38 ntu) no odor, **EL** (13 ntu) astringent odor, melosira, cyclotella, synedra, Nitzschia, blue-green algae, asterionella, trachelomonas; **lagoon** (2 ntu) strong fishy odor, planktonic bacteria; **filter influent** fishy/musty, sloughed matter, planktonic bacteria, algae; **filter effluent** musty/fishy, cymbella; **tap water** musty odor.*

Microscopic Process Evaluations

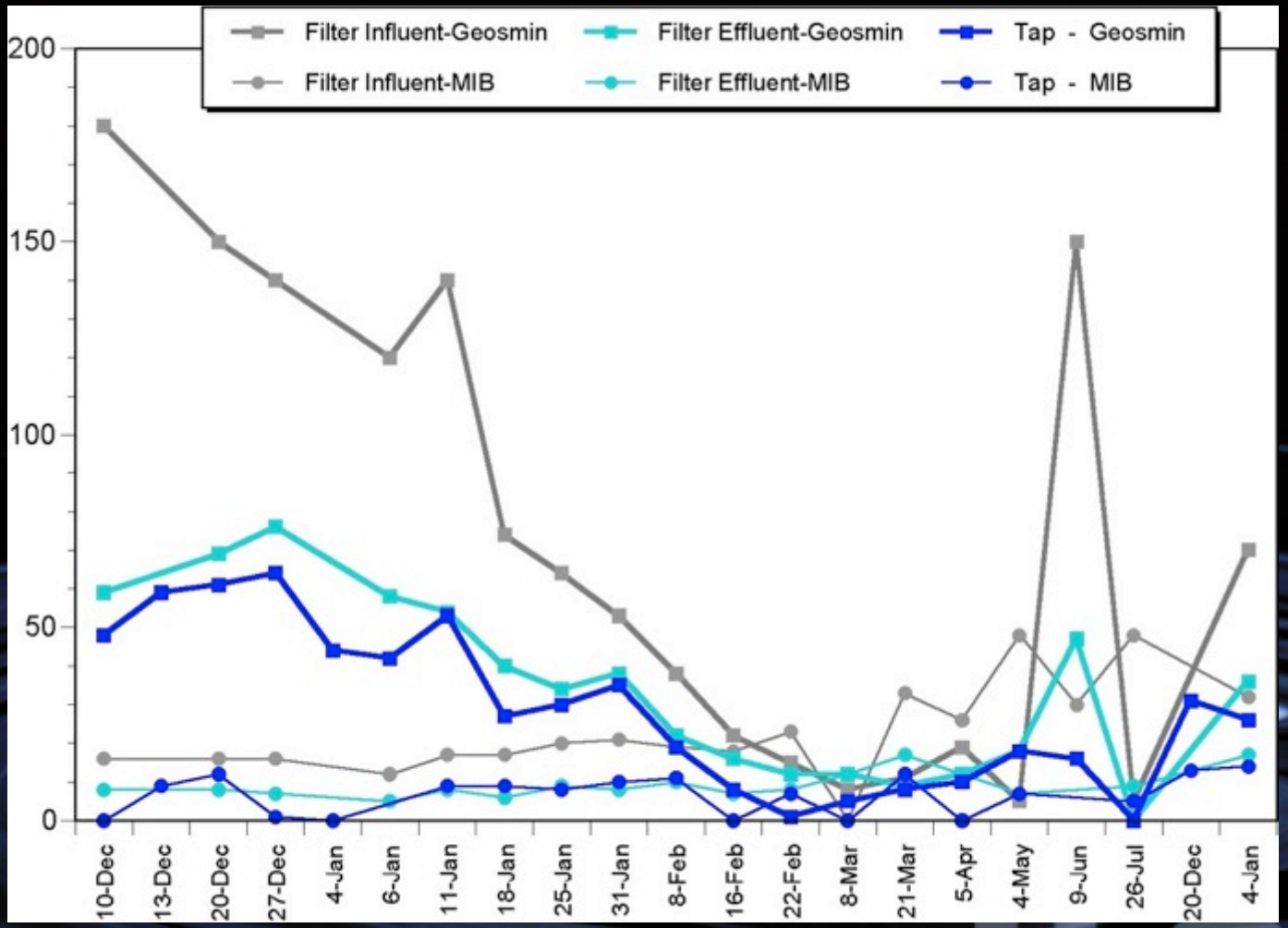
Weekly Series:
from Lakes & Lagoon to Finished Water Tap

Geosmin/MIB Monitoring



Most Geosmin/MIB removal occurs during filtration

Removal of Geosmin/MIB by Filtration



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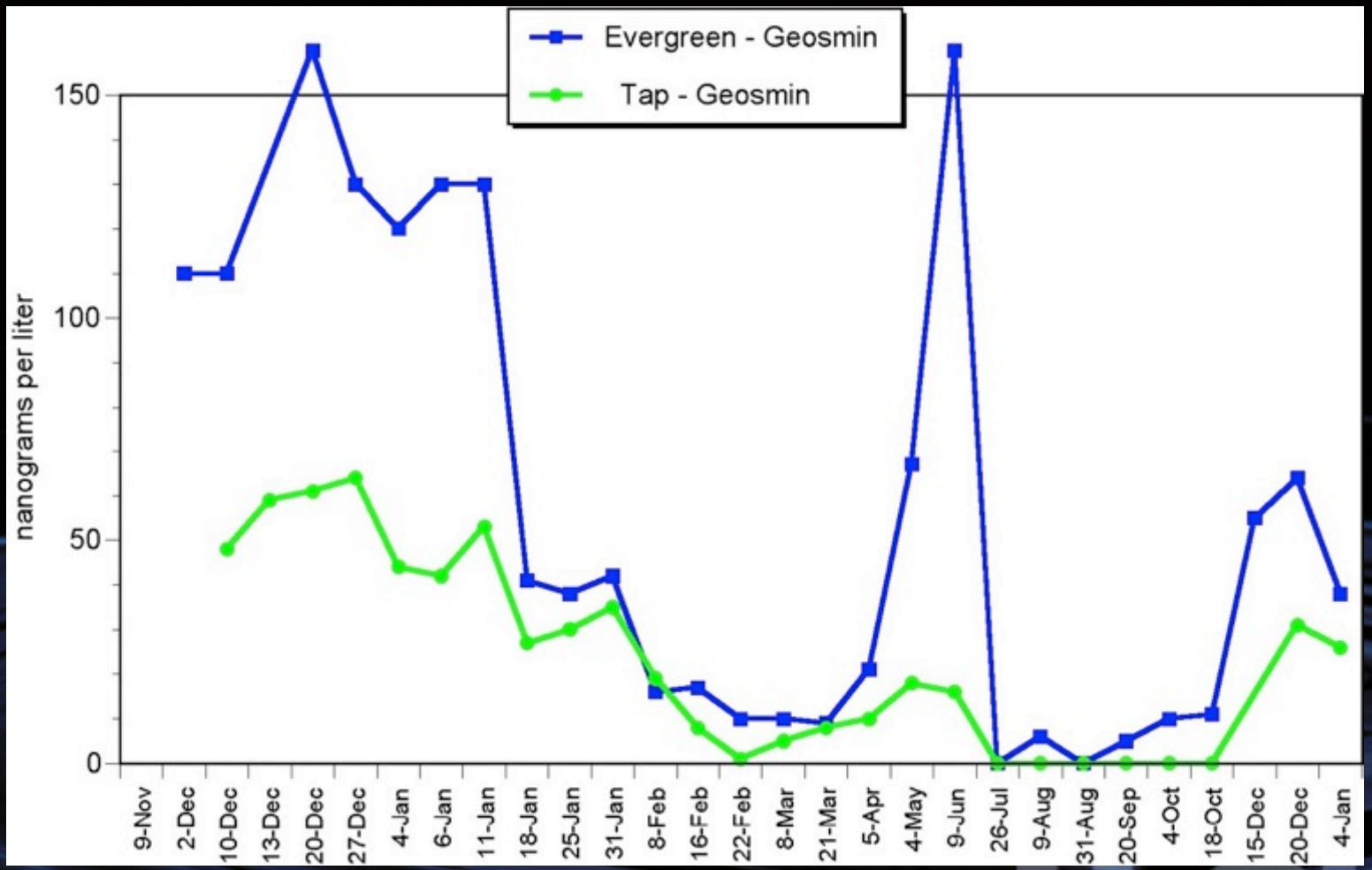
Overall Plant Removal of Geosmin



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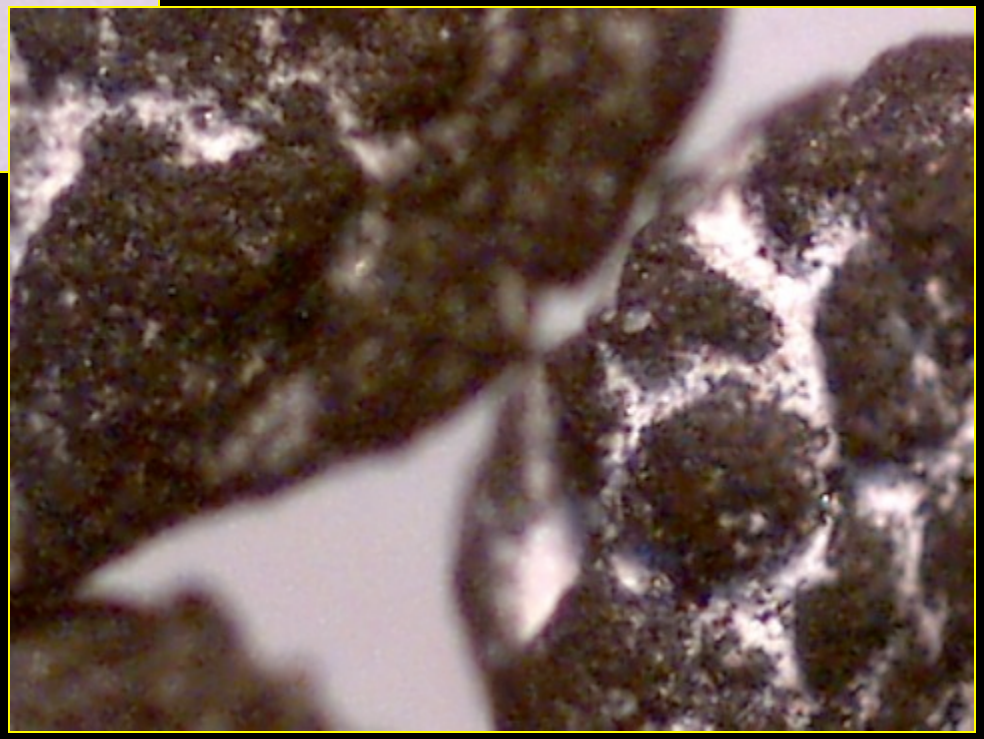
Bloomington, Illinois
GAC Filter Caps
24-inch deep filter cap
replaced with virgin
GAC after two years

Virgin versus Microbially-Colonized GAC Granules



Stalked Bacteria on Granular Activated Carbon

Bloomington WTP Laboratory
Column Studies of Removal of Geosmin by GAC

Assessment of Factors Affecting GAC Removal of Geosmin

GAC Age/Condition:	**virgin GAC (minimal microbial growth)**
	GAC in service for one-year
	GAC in service for two years
Contact Time:	**GAC in service for two years at twice EBCT**
Temperature:	**winter vs. summer operating conditions**

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GAC Column Studies

Geosmin-spiked column influent

GAC columns (4)

Geosmin, TOC sample bottles

Luminescent DO Meter (oxygen depletion)


Geosmin-spiked
GAC Column Influent
L. BLOOMINGTON
FILTER INFLUENT
450 ng/L GEOSMIN

GAC Columns

1. Fresh (Virgin)
2. One-Year-Old
3. Two-Year-Old
4. Two-Year-Old
   @ twice EBCT

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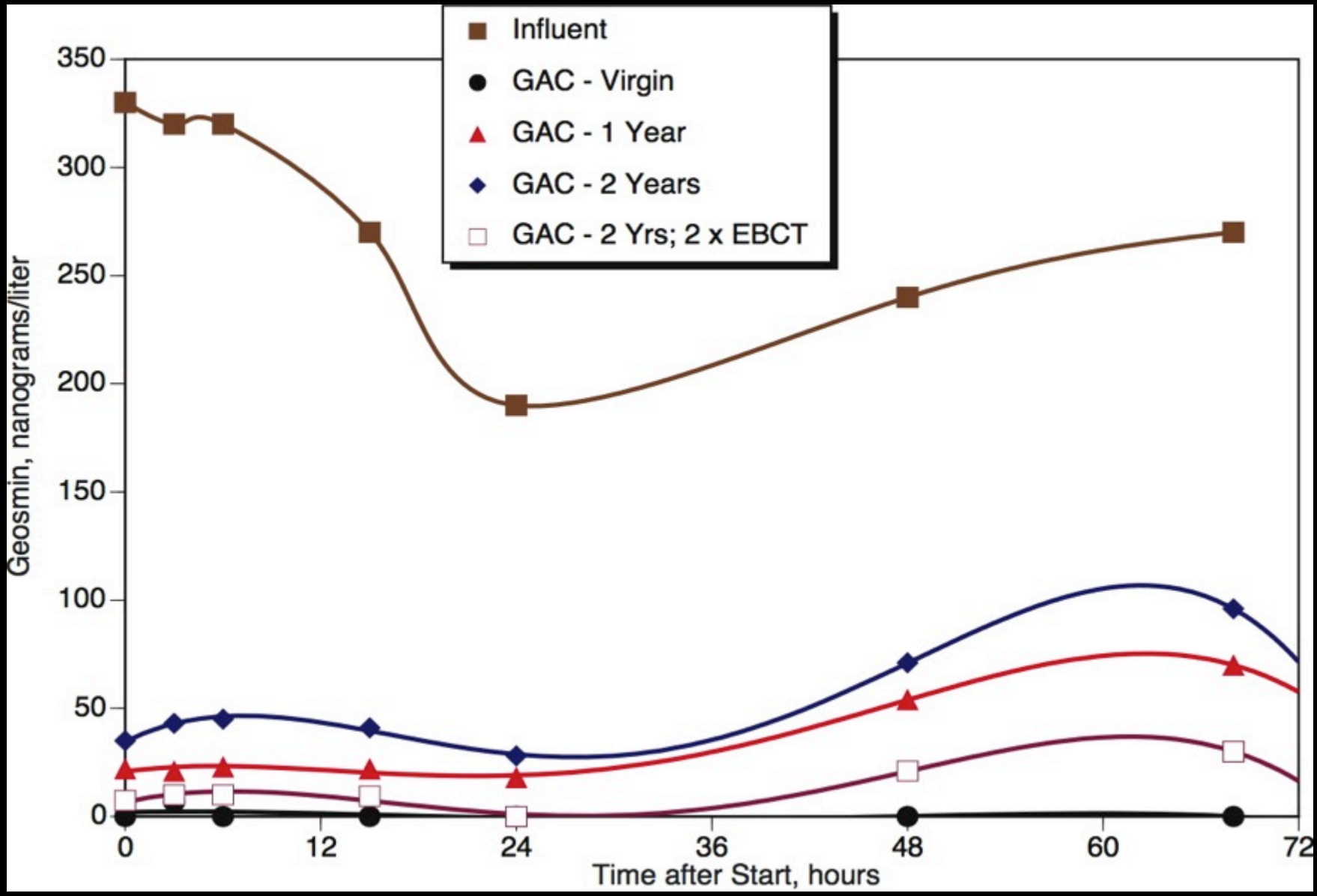
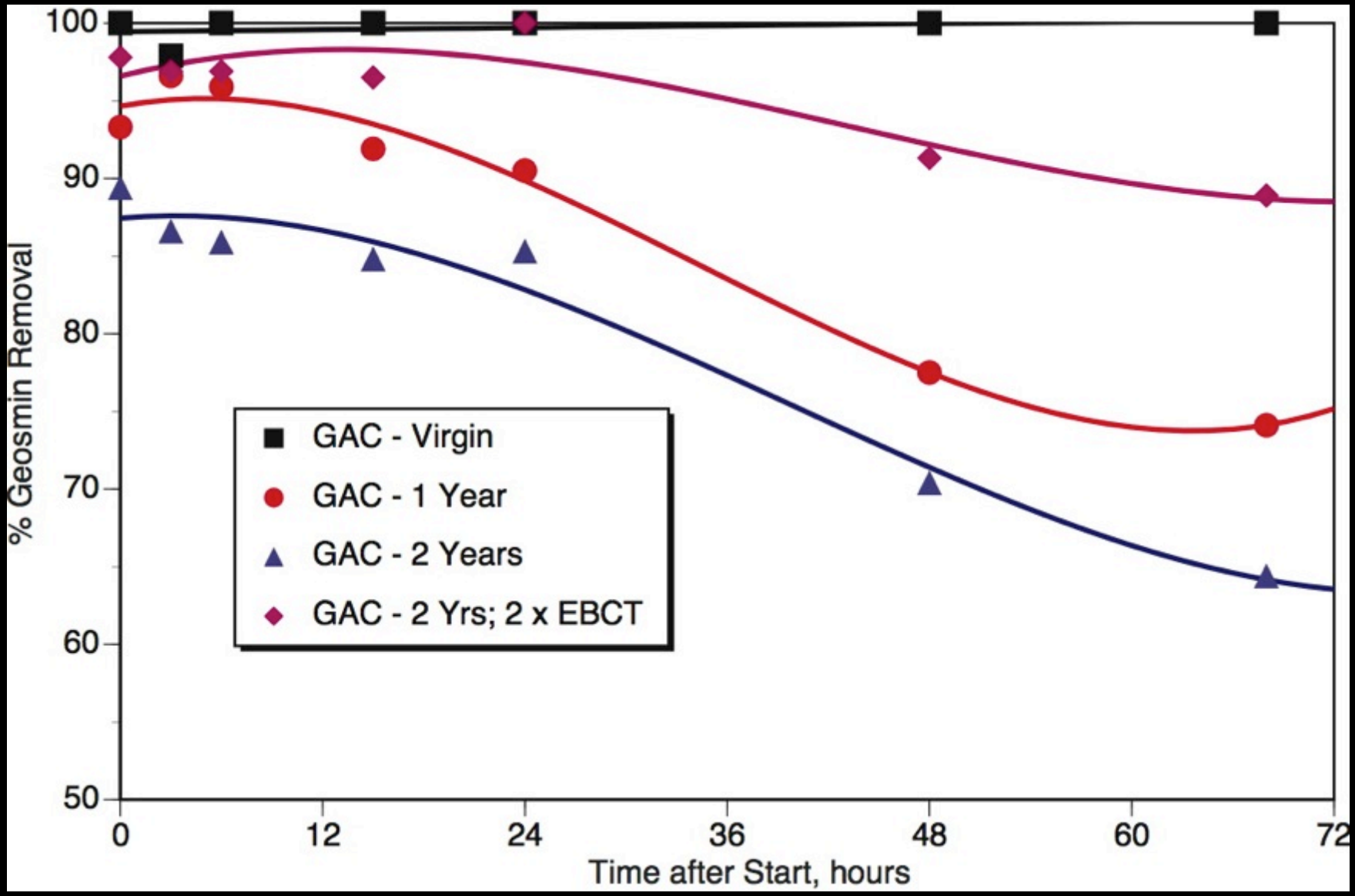
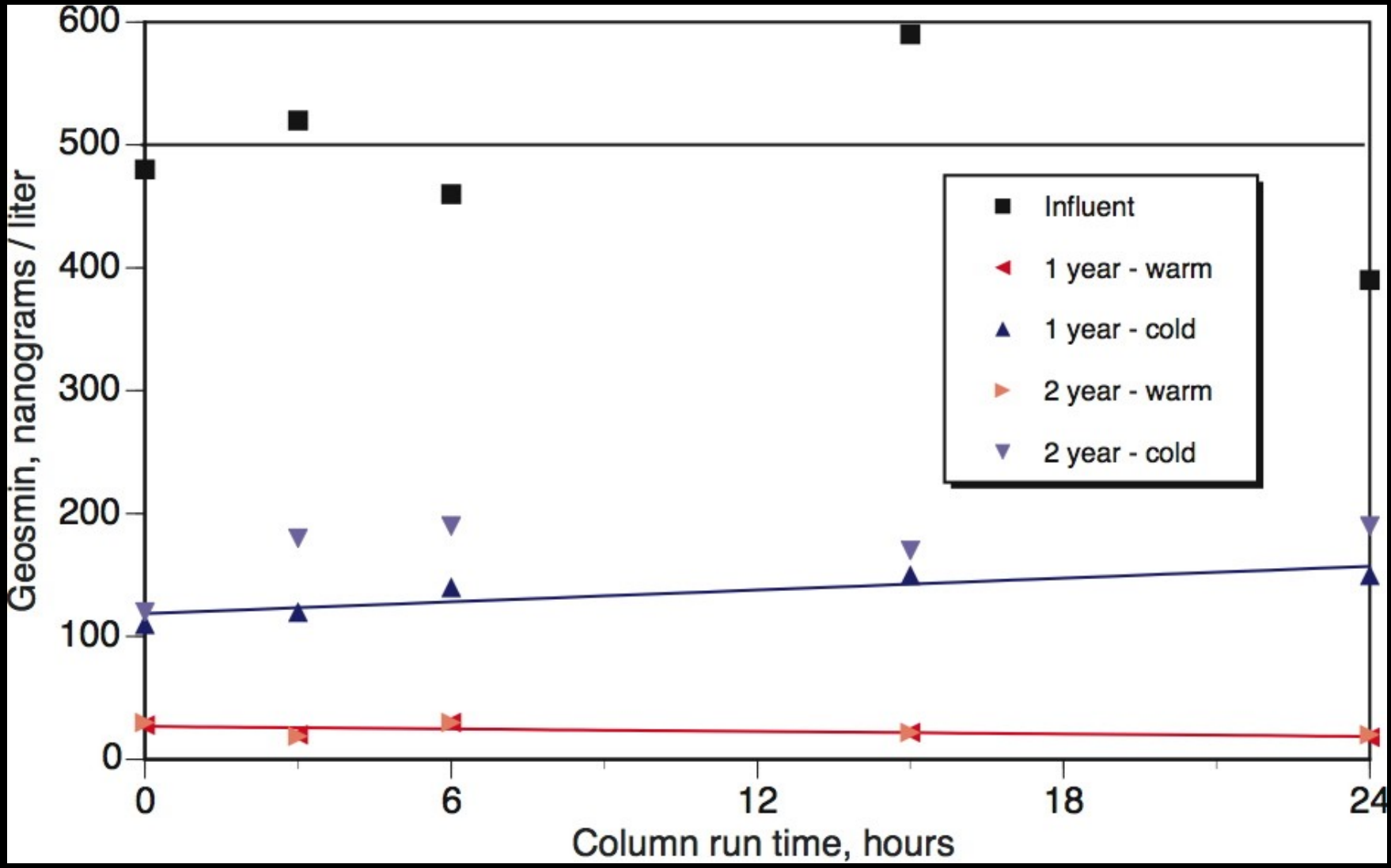
Removal of Geosmin on GAC

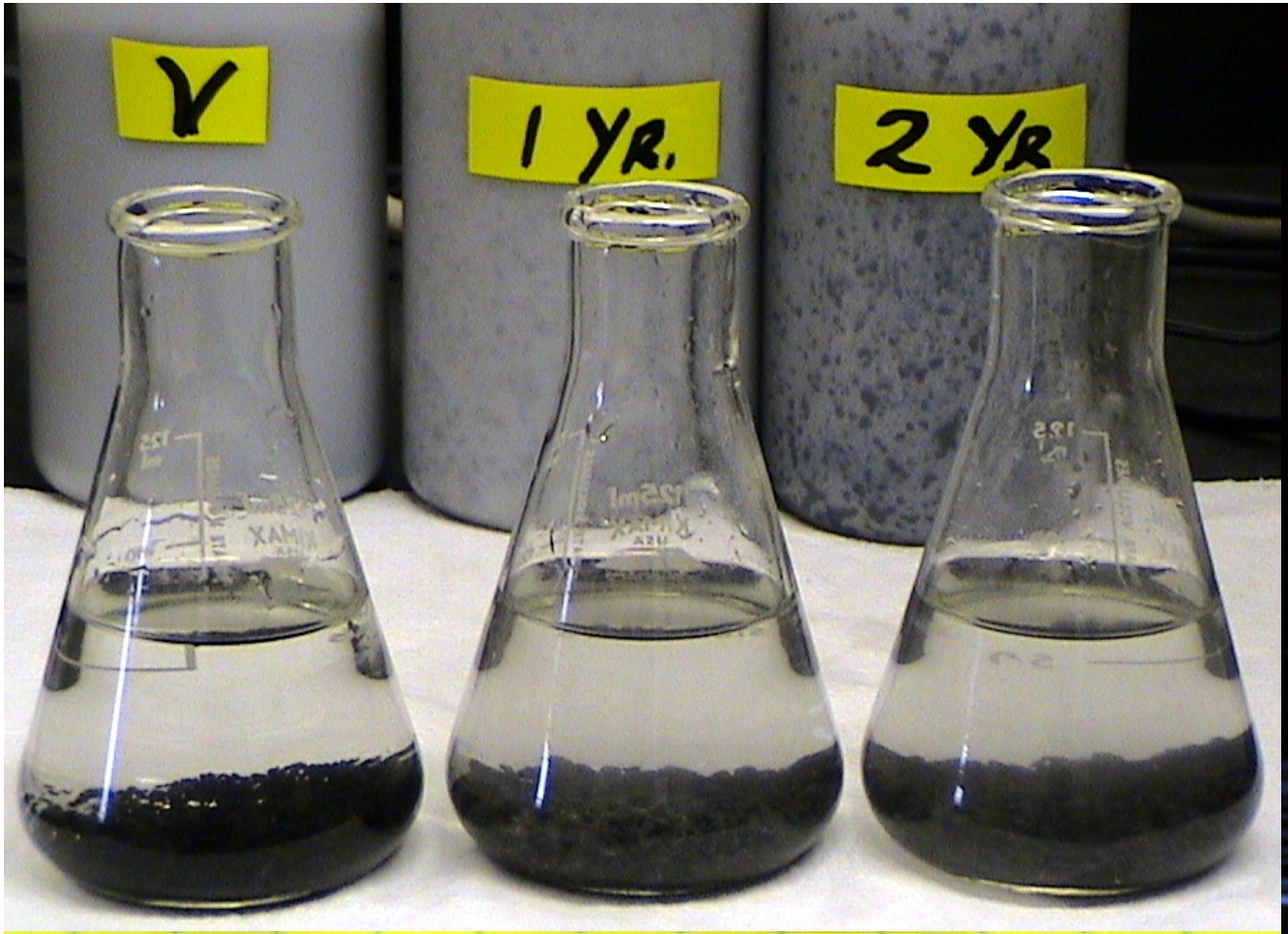


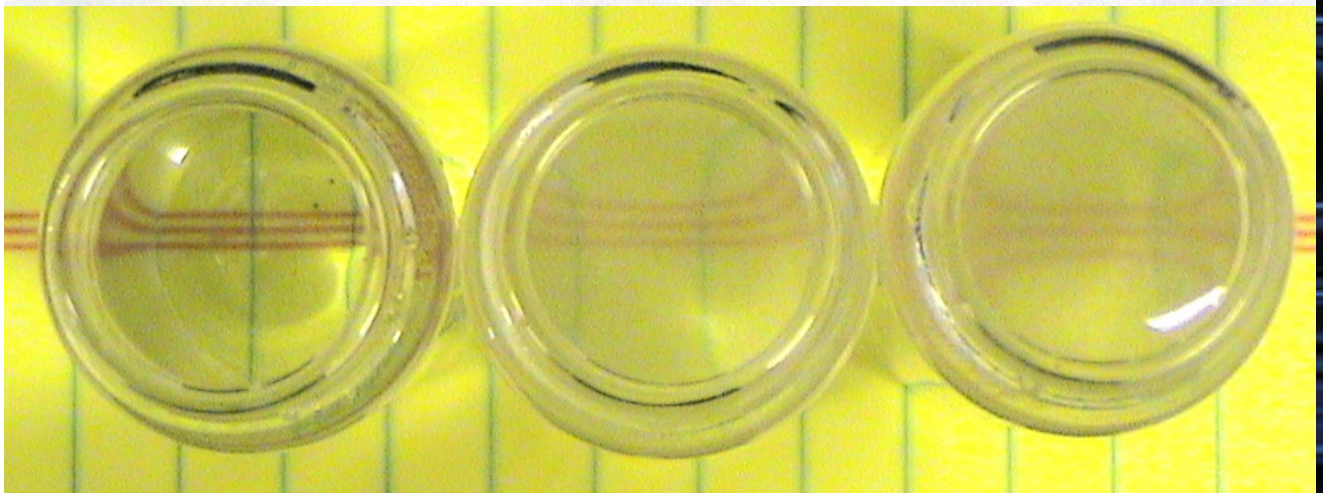
Percent Removal of Geosmin



Effect of Temperature on Geosmin Removal







Turbidity of GAC Rinse Water

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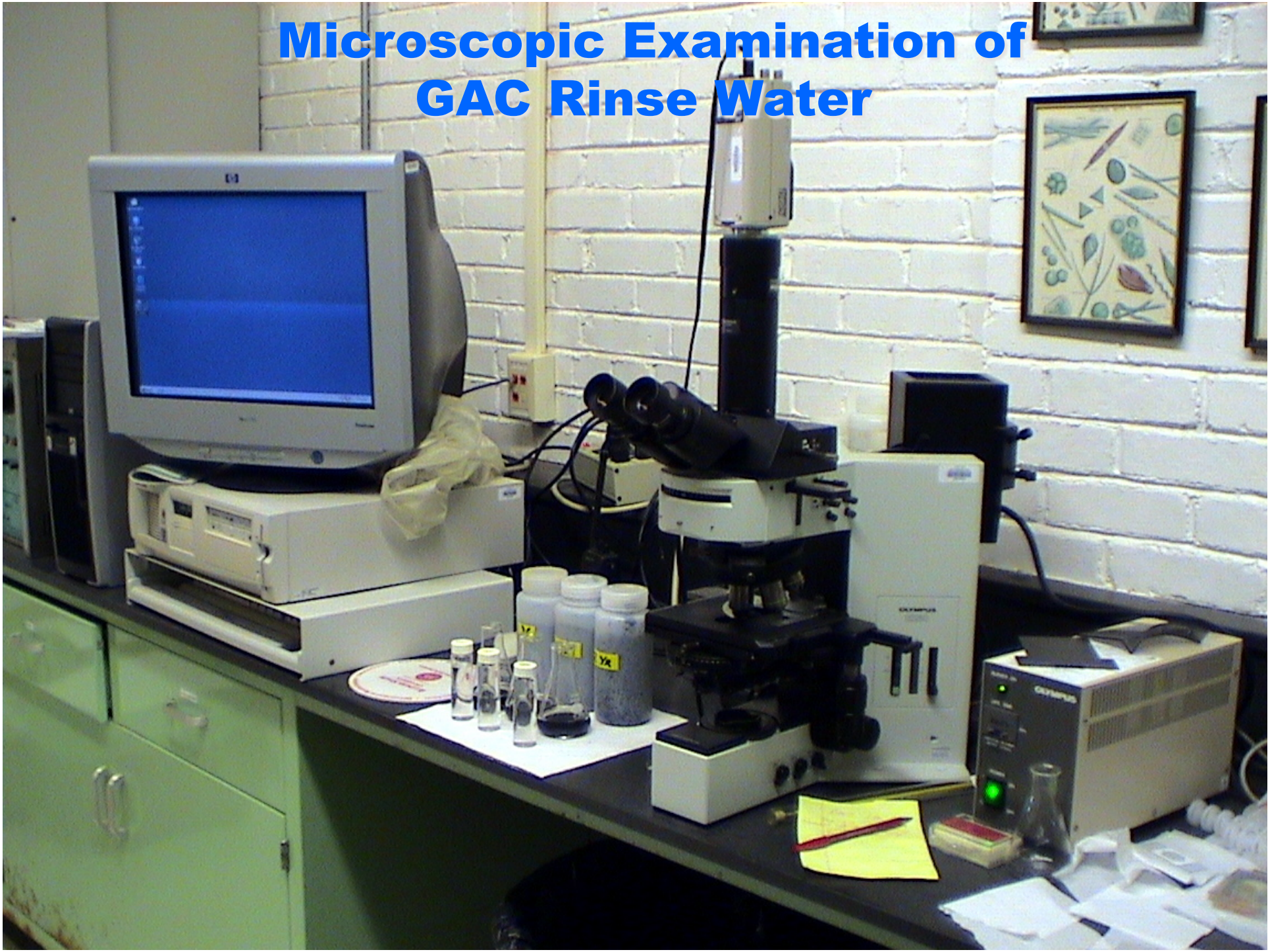
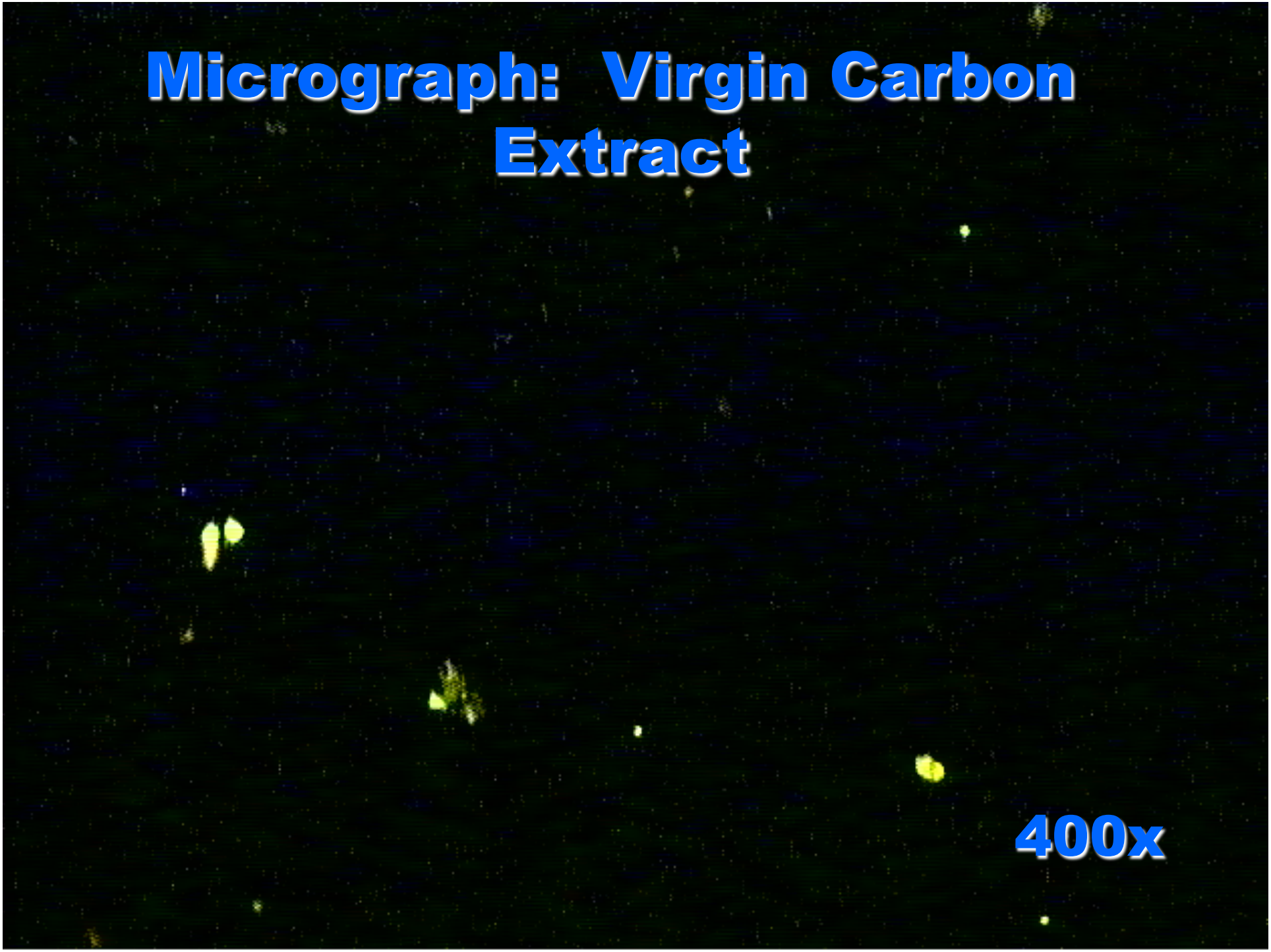
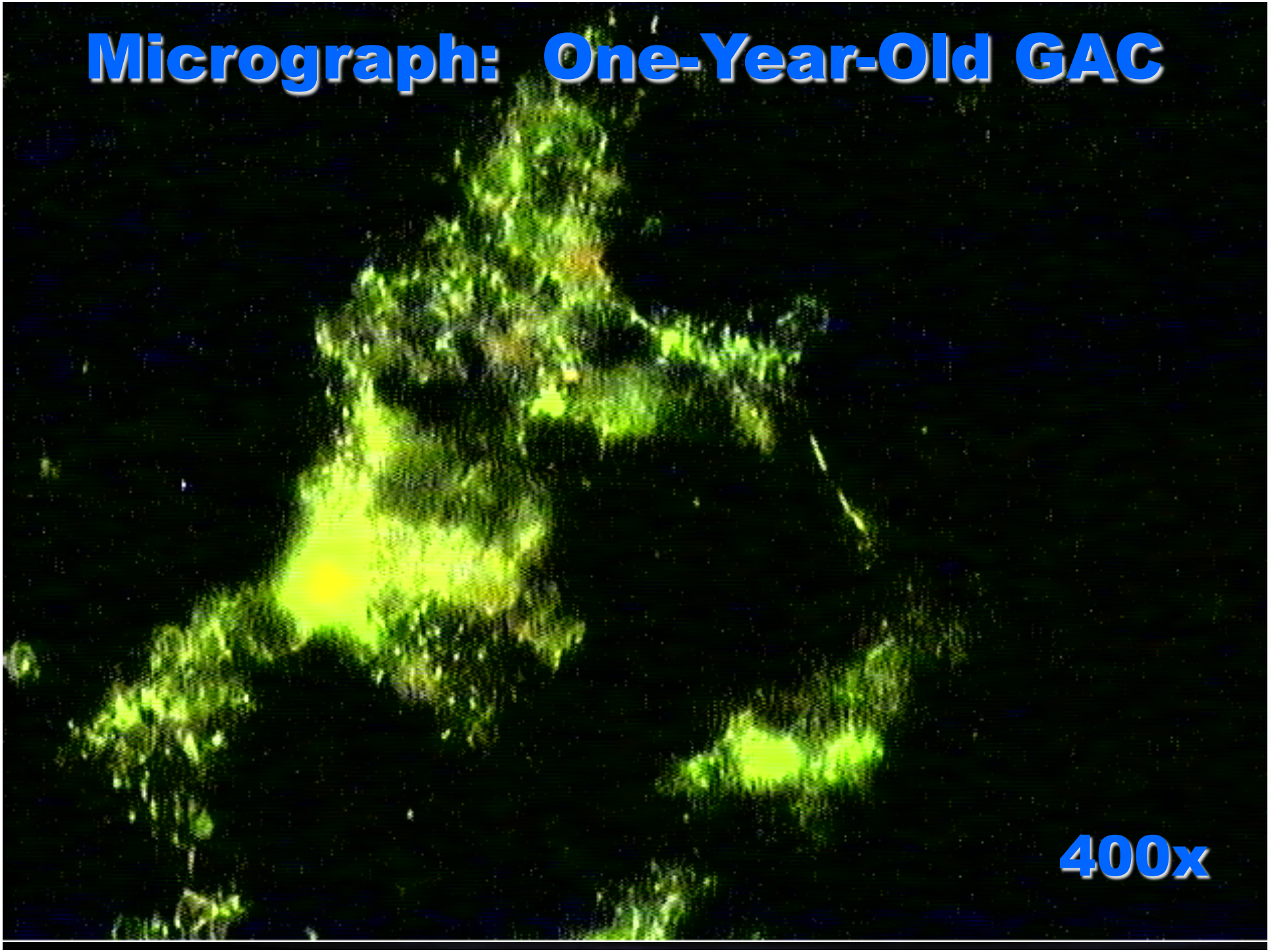
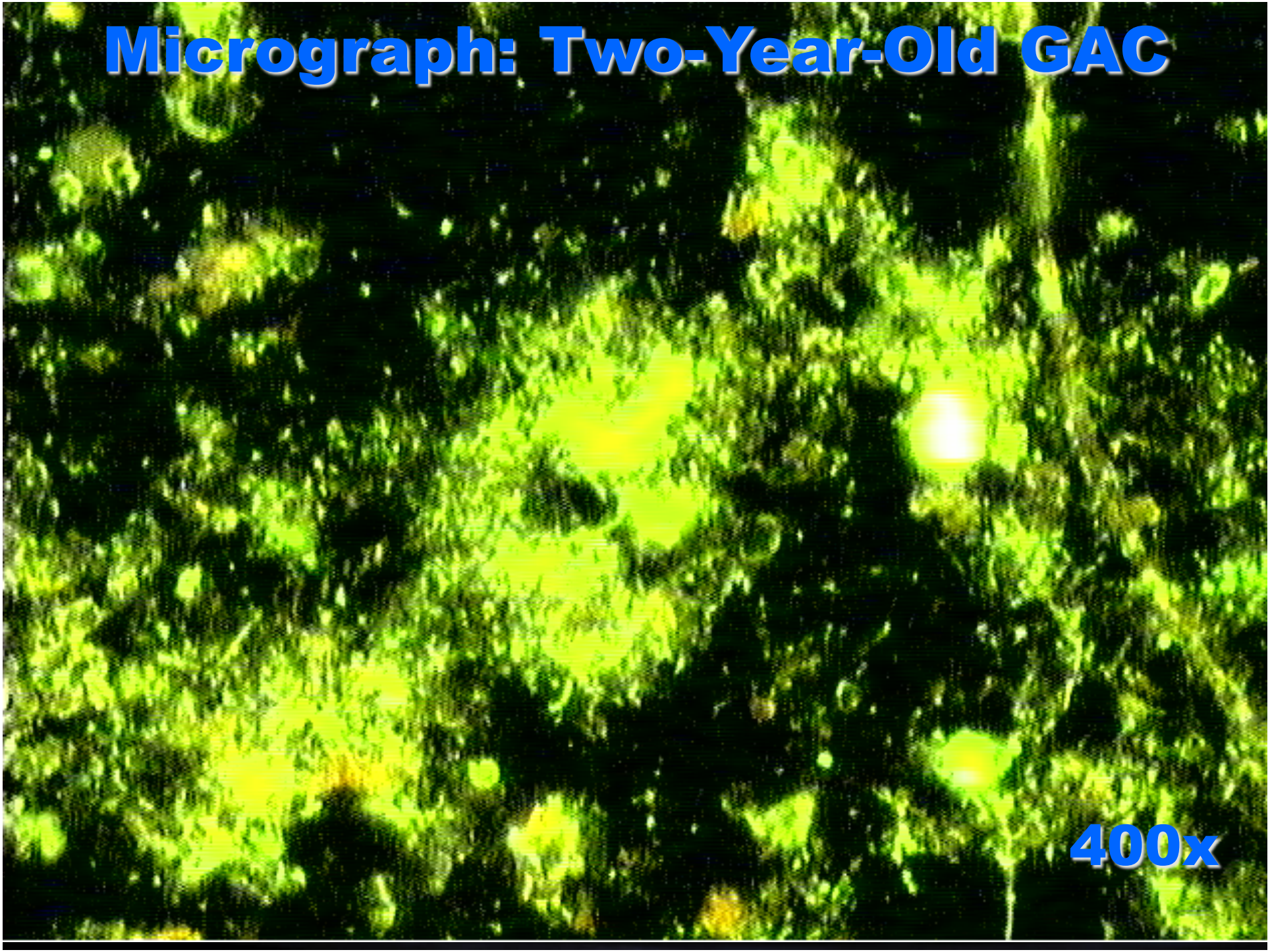
Microscopic Examination of GAC Rinse Water

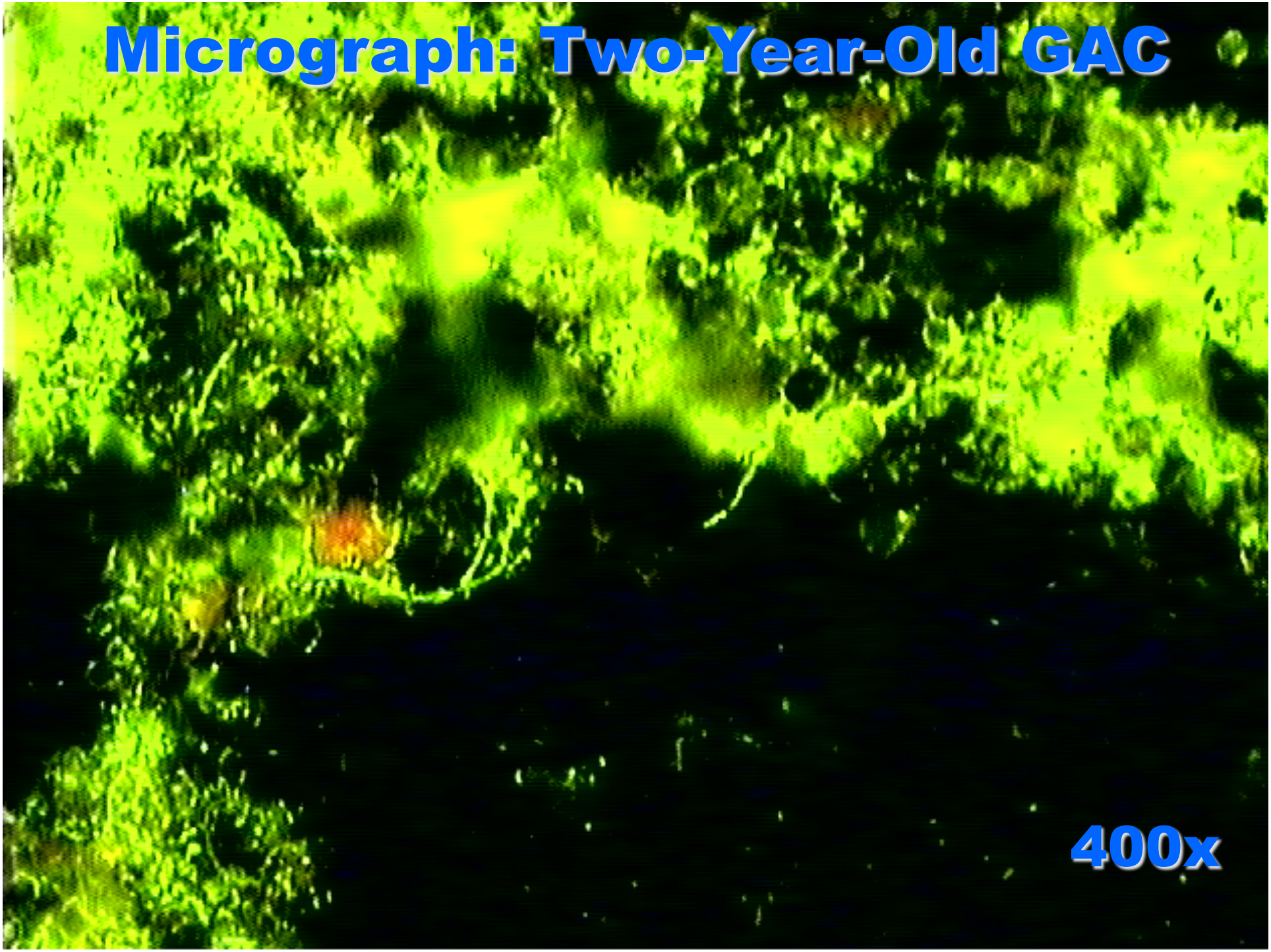


Micrograph: Virgin Carbon Extract




Micrograph: One-Year-Old GAC
400x


Micrograph: Two-Year-Old GAC
400x


Micrograph: Two-Year-Old GAC
400x

Additional Testing

Aeration stripping of volatile compounds

Ozonation stripping plus oxidation

Chemical Oxidation

potassium permanganate,
chlorine dioxide,
Fenton's reagent,
hydrogen peroxide + ultraviolet light

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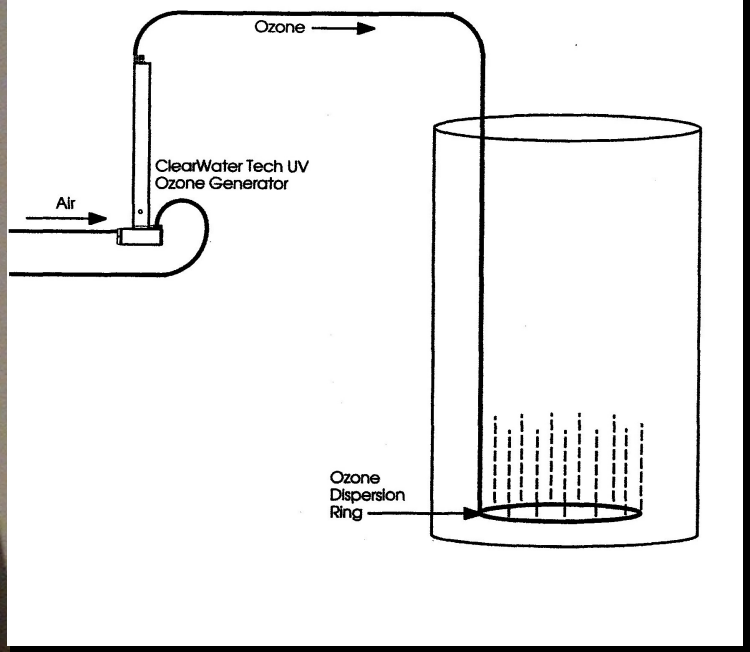
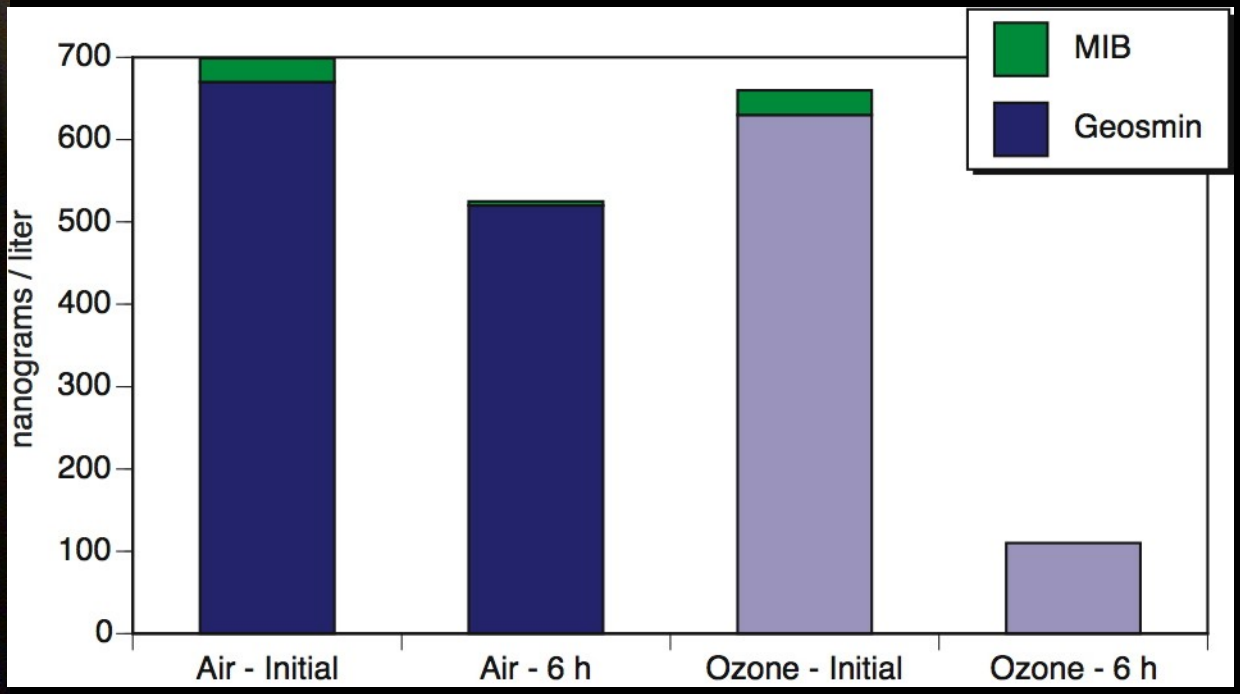


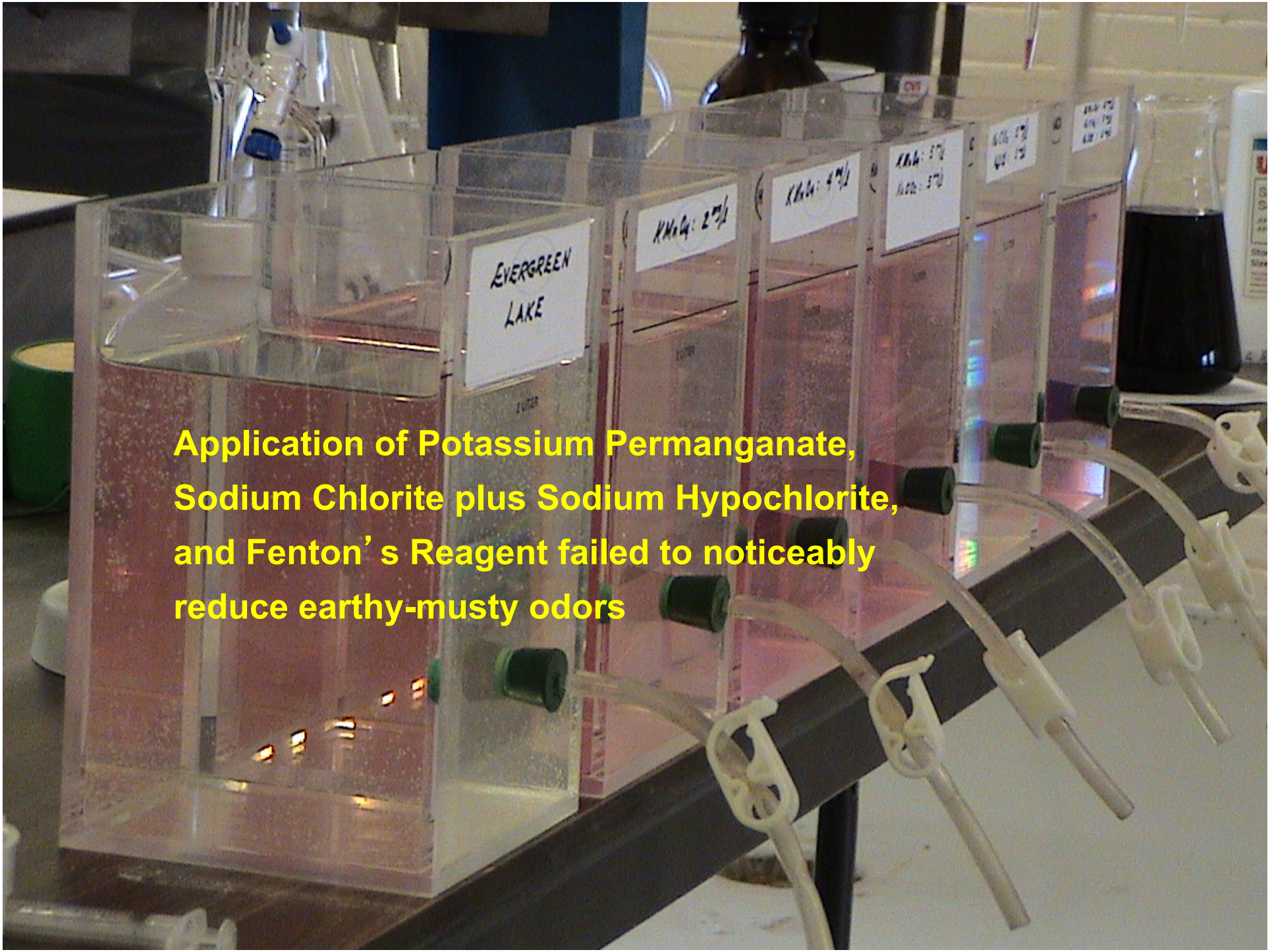
Ozonation

reduces geosmin, *but* imparts ozonous odor

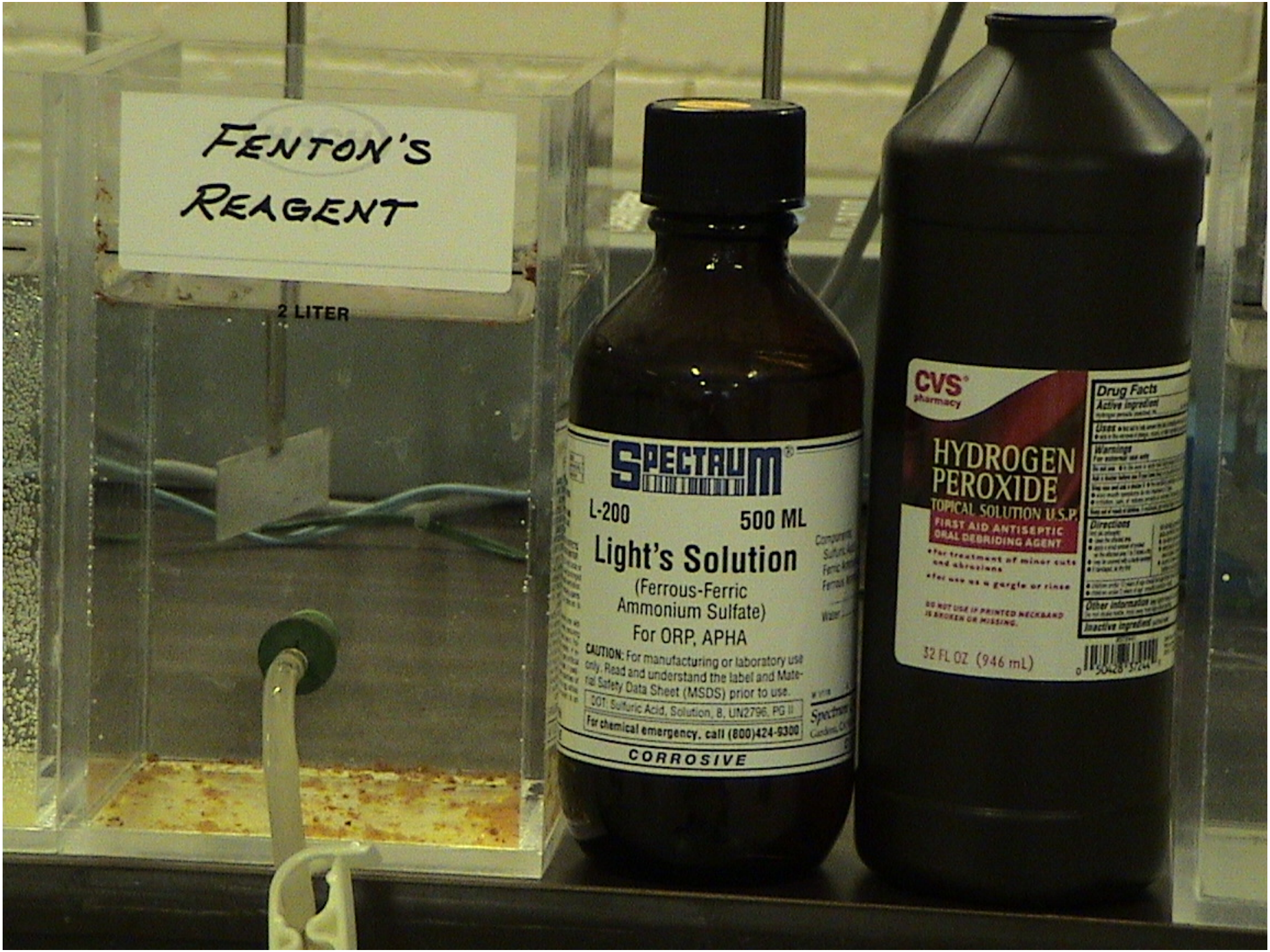
Aeration

29% geosmin reduction due to aeration alone





Application of Potassium Permanganate, Sodium Chlorite plus Sodium Hypochlorite, and Fenton's Reagent failed to noticeably reduce earthy-musty odors


FENTON'S
REAGENT
2 LITER
SPECTRUM
L-200
500 ML
Light's Solution
(Ferrous-Ferric
Ammonium Sulfate)
For ORP, APHA
CAUTION: For manufacturing or laboratory use only. Read and understand the label and Material Safety Data Sheet (MSDS) prior to use.
DOT: Sulfuric Acid, Solution, 8, UN2796, PG II
For chemical emergency, call (800)424-9300
CORROSIVE
CVS pharmacy
HYDROGEN
PEROXIDE
TOPICAL SOLUTION U.S.P.
FIRST AID ANTISEPTIC
ORAL DEBRIDING AGENT
Drug Facts
Active ingredient
Uses
Warnings
Directions
Other information
Inactive ingredient
32 FL OZ (946 mL)

Removal of Geosmin by UV-Peroxide

Removal of Geosmin by UV-Peroxide

Initial H_2O_2 dosages and UV retention times inadequate for effective oxidation;

Subsequently, very high dosages were found effective

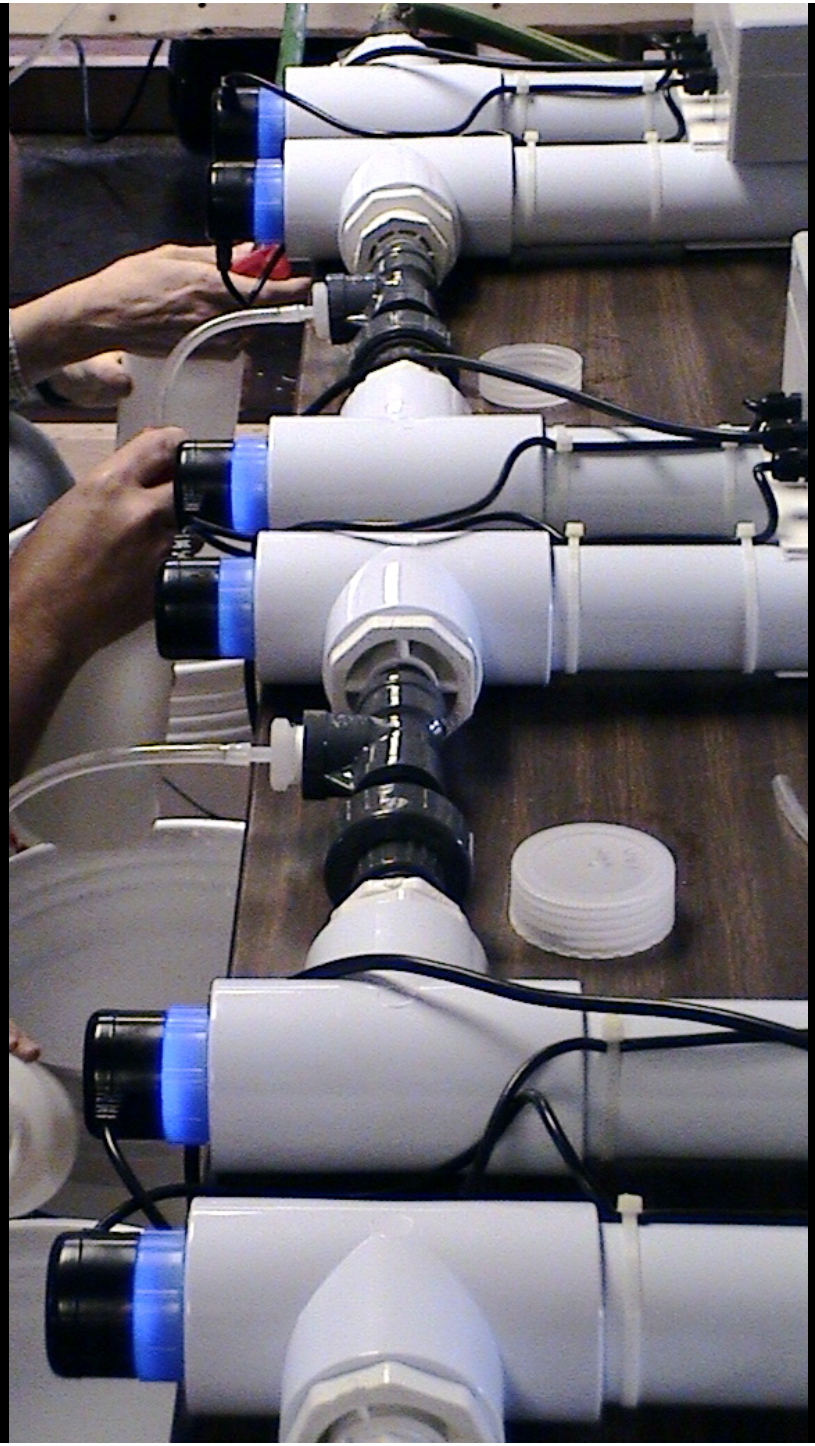
Removal of Geosmin by UV-Peroxide

Influent Geosmin: 350 ng/l

H_2O_2 dosage: 30 mg/l

UV dosage: 38 J/cm^2

Effluent Geosmin: ND



Conclusion

Source of taste and odor: blue-green algae

Occurrence: Frequency, Season, Geosmin with depth

Lagoon Storage of Sludge with Retained Algae

Removal: GAC adsorption

GAC biodegradation

Adverse effect of low temperature

Maximize GAC EBCT

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Conclusion

Predict monitor nutrients, algal populations, dissolved oxygen, temperature, microcystins, blue-green pigment, UV_{254} , and TASTE THE WATER

Pre-empt lake destratification, avoid lagoon recycle (discharge permit pending), avoid pre-oxidation

Remove GAC adsorption / biodegradation

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Acknowledgements

Ron Stanley, lab technician

and the

Staff of the Bloomington Water Treatment Plant